Impact of Typhoons on the Western Pacific: Temporal and horizontal variability of SST cooling Annual Report, 2020

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Long-term Goals/Scientific Background

This project is now in the first half of the third year (the field phase) of the ITOP program. The long term goal is to understand how the spatial variation of ocean and hurricane parameters, e.g., upper ocean temperature gradient, initial mixed-layer depth, etc., contribute to hurricane-ocean interaction. With this understanding we should then be in position to make better forecasts of hurricane-ocean interaction, and especially of hurricane intensity (Emanuel et al., 2004).

The phenomenon of direct interest is the cooling of SST caused by hurricanes and typhoons, by up to 2 to 5°C (Price et al., 1994; Sanford et al., 2007; Cornillon et al., 1987). This SST cooling is observed to vary temporally - disappearing in O(10) days (Price et al., 2008), and spatially. The most impressive spatial variation of the cool wake seen behind moving hurricanes is that SST cooling is significantly biased to the right side of the hurricane track (looking in the direction of the hurricane motion) for translation speeds greater than about 2-3 m/sec. There is almost always observed to be a substantial variation of SST cooling in the direction *parallel* to a hurricane track as well. Factors that could cause along-track variation of cooling include spatial variation in the pre-hurricane oceanic temperature (and salinity) stratification, and

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of course spatial variation of the hurricane intensity and translation speed. This along-track variation of cooling has been a particular focus of this project, along with the wake warming.

Objectives

The objective of this project is to implement ocean models and diagnostics that are applicable to forecasting SST cooling, and after the fact, to help understand what factors contribute to hurricane/ocean interaction. One form of this developed in the previous year of this project is a depth-averaged temperature, T_{100}, that is an estimate of the SST in a hurricane wake. To be sure, T_{100} is most appropriate for intense hurricane, e.g., Hurricane Frances from the 2004 CBLAST field program. A more complex version has also been developed, T_d, where the d refers to a variable depth of mixing, that depends upon hurricane translation speed, intensity, etc. So far, T_{100} has been the clear choice for operational modelling groups, no doubt for its simplicity.

Approach

The main tool for developing diagnostic variables has been guidance from numerical models (Price et al., 1994) and careful study of field observation, firstly CBLAST 2004, and in the future, ITOP/TCS10. ITOP will provide several additional examples of cool wake evolution, and far greater detail from *in situ* ocean data than has ever been available before. The 2010 hurricane season was especially notable in the North Atlantic, yielding several striking examples of hurricane cool wakes (Fig. 1). These cases will not include the detail of ocean data coming from ITOP, but will nevertheless make useful test cases.

Work Completed/Results

During the previous year, 2009, the possibility of an improved ocean diagnostic (or metric) was described in Price (2009). There it was argued that a depth-averaged temperature, e.g., T_{100}, should be preferable to a depth-integrated temperature, the present hurricane-ocean metric usually called Upper Ocean Heat Content, or OHC (Goni and Trinanes, 2003; Lin et al., 2008). What it did not do was show that T_{100} was superior in practice. In the past year the main effort has been to make the new diagnostic available for use by operational groups (Goni et al., 2009).

Impact/Applications

The new metric, T_{100} has been taken up for operational testing alongside OHC in the East Asian Sea Forecasting System of NRL and Dr. Dong-Shan Ko. It also routinely computed by the University of Miami hurricane modeling group (S. Chen and colleagues) and by the National Taiwan University remote sensing laboratory (I-I Lin and colleagues). So far we can say informally that T_{100} gives a plausible

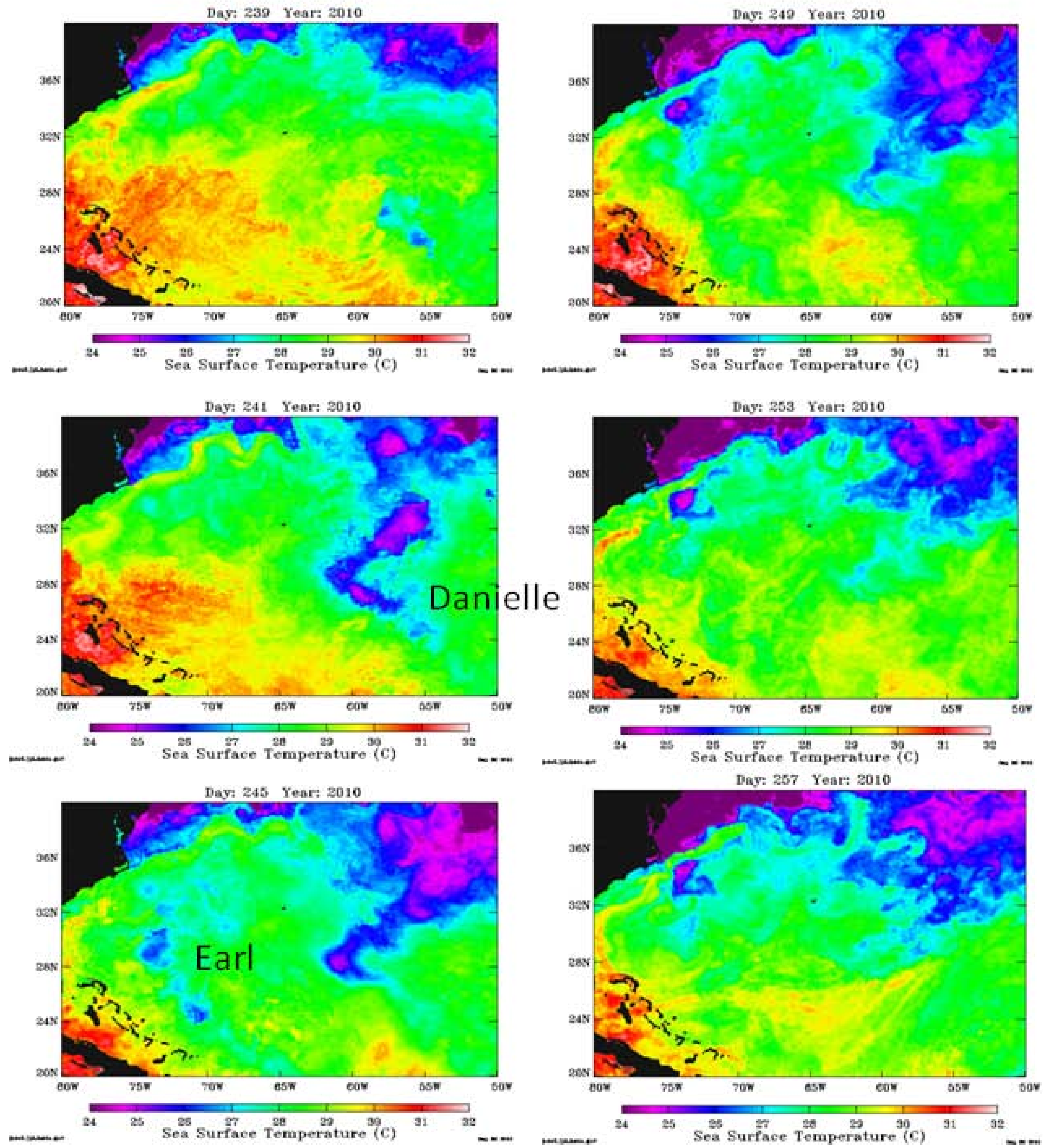

Figure 1: Six daily images of SST from the 2010 North Atlantic hurricane season. The year day of each image is at the top of the image. Time runs down the left column, and then down the right column. The cool wakes of Hurricanes Danielle and Earl are clearly evident. Note the marked along-track variation of cooling. Some of this was no doubt due to variations in hurricane properties (translation speed and intensity, mainly) and some part was due also to variation within the ocean. The T_{100} diagnostic aims at the latter. Note also the fairly rapid disappearance of the cool wake behind Danielle, and for the most part following Earl, e-folding in from 5 to 10 days. A much larger collection of these images is available online from http://www.whoi.edu/science/PO/people/jprice/ekman/2010-NAtl-SST.zip These data are from the JPL POET data server, and are the Level 4 merged SST analysis of Remote Sensing Systems.

estimate of SST cooling to intense or slowly moving hurricanes. It appears to overestimate cooling to weak or very rapidly moving storms. T_d would be preferred for those cases.

Collaborations

The PI has collaborations ongoing with Dr. Tom Sanford, APL/UW (Sanford et al., 2010), Prof. Shuyi Chen of RSMAS Univeristry of Miami and Prof. I-I Lin of National Taiwan University.

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